Preface

The studies of particles advected by tubulent flows is an active area of research across many streams of sciences and engineering, which include astrophysics, fluid mechanics, statistical physics, nonlinear dynamics, and also chemistry and biology. Advances in experimental techniques and high performance computing have made it possible to investigate the properties these particles advected by fluid flows at very high Reynolds numbers. The main focus of this thesis is to study the statistics of Lagrangian tracers and heavy inertial particles in hydrodynamic and magnetohydrodynamic (MHD) turbulent flows by using direct numerical simulations (DNSs). We also study the statistics of particles in model stochastic flows; and we compare our results for such models with those that we obtain from DNSs of hydrodynamic equations. We uncover some of aspects of the statistical properties of particle trajectories that have not been looked at so far. In the last part of the thesis we present some results that we have obtained by solving the three-dimensional Euler equation by using a new method based on the Cauchy-Lagrange formulation.

This thesis is divided into 6 chapters. Chapter 1 contains an introduction to the background material that is required for this thesis; it also contains an outline of the problems we study in subsequent Chapters. Chapter 2 contains our study of "Persistence and first-passage time problems with particles in three-dimensional, homogeneous, and isotropic turbulence". Chapter 3 is devoted to our study of "Universal Statistical Properties of Inertial-particle Trajectories in Three-dimensional, Homogeneous, Isotropic, Fluid Turbulence". Chapter 4 deals with "Time irreversibility of Inertial-particle trajectories in Homogeneous, Isotropic, Fluid Turbulence". Chapter 5 contains our study of the "Statistics of charged inertial particles in three-dimensional magnetohydrodynamic (MHD) turbulence". Chapter 6 is devoted to our study of "The Cauchy-Lagrange method for the numerical integration of the three-dimensional Euler equation".